1. A proportionate decrease in both systolic and diastolic blood-pressure during the training period.

2. With a period of rest succeeding the training period, a rise of systolic and diastolic blood-pressure beyond the anteseason records.

3. The blood-pressure reaction to the given test of fifty stationary running steps is scarcely altered by a period of training.

As a basis for explanation for these phenomena several hypotheses may be stated:

(*a*) *Vascular Influence.* The decrease of blood-pressure during training may result from an enlargement of the vessels to the skeletal muscles with lessened peripheral resistance. Or this lessened peripheral resistance may result from a compensatory vasodilatation to accommodate for the increase in cardiac output and work from athletic training. From the vascular stand-point the secondary rise of blood-pressure after a period of rest would be explained by the logical assumption of a return of normal vasomotor tone, which in the presence of a hypertrophied myocardium, or increased cardiac power, would lead to increased blood-pressure from a relative increased peripheral resistance with an accompanying increase in systolic output. Moderate peripheral sclerosis from overstrain would likewise give increased resistance with a tendency to higher blood-pressure than normally existed in a given individual.

(*b*) *Cardiac Influence.* The primary decrease in blood-pressure after a period of training may be the result of a temporary moderate cardiac dilatation. By regaining normal myocardial tone with rest and the development of cardiac hypertrophy the increase of blood-pressure during this period may be explained.

Perhaps both of these factors are active in the production of the phenomena.

THE ADMINISTRATION OF GLUCOSE SOLUTIONS AS A PROPHYLACTIC AGAINST POST-OPERATIVE SHOCK.

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IN a recent article[1] the writer has called attention to the present status of our knowledge of the various methods of parenteral nutrition. From the experimental data cited, it is apparent that, theoretically and practically, an animal may be kept for a considerable period in nitrogen equilibrium and at a constant weight by the intravenous injection of solutions containing amino-acids and glucose (Henrigues and Anderson). The subcutaneous administration of fats is possible, and they are apparently metabolized and supply a portion of caloric need of the organism.

[1] Parenteral Nutrition and its Surgical Application, Med. Record, July 25, 1914.

For practical purposes, however, of the three main groups of nutritives—fats, proteids, and carbohydrates—only one (carbohydrate in the form of glucose solution) is available for the surgeon in the treatment of those accidents and disagreeable symptoms which may accompany, or occur shortly after, a major operation.

It is the desire, further, to emphasize the value of glucose solutions as a prophylactic against some of the unpleasant post-operative complications, as well as to call attention to the methods of its administration, that has led to the preparation of this article.

It may be stated as a postulate that patients who are well nourished stand operation better than patients who are poorly nourished. This is apparent to all, but the fact that patients are frequently underfed for a period of several days before operation is often regarded as of little moment. A patient who is well nourished has food material stored in his tissues to supply his requirements for a short period. This is principally in the form of glycogen and amino-acids, which are present in the liver and blood, and may be called upon in sudden emergencies. It is not sufficiently appreciated that after the first twenty-four hours these circulating and stored nutritives are largely exhausted, and after that time the body requirements are met almost wholly by the utilization of proteid and fat derived from the patient's own tissues.

It has long been recognized that starvation produces a condition known as acidosis, and that this same condition occurs after several days of a strict carbohydrate-free diet; or, pathologically, in patients suffering from diabetes who are unable to utilize the carbohydrates present in their food. The same condition also occurs in certain types of metabolic disturbances in children, in some cases of vomiting of pregnancy, and frequently after long anesthesia.

Acidosis should be recognized as a condition—not as a definite pathological process—the salient characteristic of which is the excretion of acetone bodies in the urine (and breath) and a marked increase in the titrable acid in the urine. It is commonly supposed that there is a condition of diminished alkalinity in the blood, but this statement has been challenged, the assertion being made that the blood is always neutral, and consequently a diminished alkalinity is impossible in that it is incompatible with life. The determination of the reaction of the blood is fortunately not essential for the comprehension of the clinical importance of acidosis. Whether the blood be acid, or alkaline, or neutral, there is in this condition a great decrease in available alkalies, and this, carried to the extreme, always ends in coma and death. Emerson has characterized the condition as "alkali starvation."

In the management of those diseases which are commonly classified as surgical, there are two conditions which are recognized as giving rise to acid intoxications, or acidosis. The most common type is that following anesthesia, which occurs to an appreciable

degree after from 30 to 60 per cent. of all anesthesias. The acidosis following starvation, as it occurs in those diseases associated with the inability to retain nourishment because of persistent vomiting, is not uncommon among surgical patients, and when it occurs is considerably less amenable to treatment than the uncomplicated post-anesthetic acidosis. The acid intoxication following both of these factors acting together has been found to be much more severe than that following either acting alone. That this is true is shown both by laboratory experiments and clinical experience. Experimental evidence points to starvation as the predominant factor in acidosis following prolonged vomiting, while, as was shown by Waldvogel, the toxic action of the anesthetic had an important influence in the production of post-anesthetic acidosis. Furthermore, it has been definitely proved that acidosis may be prevented or markedly diminished by the administration of carbohydrate food. The symptoms may be relieved by the use of alkalies, but the underlying disturbance is overcome only when sufficient carbohydrate food may be absorbed and oxidized to prevent the excessive metabolism of fats and proteids.

The effect of diet upon animals poisoned with chloroform was shown by the experiments of Opie and Alford in 1914.[2] If the conditions in the human body are comparable to those in animals, and there is every reason to believe that in this respect they are the same, then this work of Opie and Alford is of the utmost importance to every surgeon, and the inference which they draw as regards diet deserves far greater application than it has yet attained.

Animals (white rats) were fed for six days upon diets which consisted solely of either fat, proteid, or carbohydrate, and at the end of that time were given what was presumably the minimum fatal dose of chloroform injected beneath the skin. The results as given by Opie and Alford are shown in the following table:

Length of Life of Animals in Days after Receiving Special Diet for Six Days.

Chloroform per 100 gm.	Diet: oats and sugar.	Diet: meat.	Diet: fat.
0.025	....	.....	L
0.05	L	11	3
0.1	10	L	1
0.15	L	L	1
0.2	L	3	2
0.25	L	3	2
Average duration of life	10+	$5\frac{2}{3}$+	$1\frac{4}{5}$

L = Lived.

From the above experiments, and others in which the results were confirmatory, Opie and Alford draw the following conclusion: "The experiments furnish evidence that fat administered to animals

[2] The Influence of Diet on Hepatic Necrosis and Toxicity of Chloroform, Jour. Amer. Med. Assoc., 1914, lxii, 895.

and presumably stored in the liver increases the susceptibility of the organ to the injurious action of chloroform. In view of the well-known solubility and diffusibility of chloroform in fats, they suggest that the fat of the liver cell determines the fixation of chloroform and occurrence of necrosis. The experiments with carbohydrates, on the contrary, furnish confirmation of the views of those who maintain that carbohydrates protect the body proteins from disintegration."

In the light of these experiments, as well as those of Waldvogel, it is important that patients about to be subjected to major surgical operations should, when possible, be put through a course of forced carbohydrate feeding for a short period immediately preceding the operation, and should receive carbohydrates in an available form soon after operation.

Secretan has called attention to the importance of giving food shortly before anesthesia as a prophylactic measure against post-operative shock. He asserts that it is usually safe to give some easily digested food from two to four hours before the anesthesia is begun. A patient in whom there is no contra-indication to oral feeding may be given a meal containing a considerable quantity of carbohydrate food in the shape of bread or cereal eight to twelve hours before operation, and a feeding which contains 100 to 200 calories in the shape of easily absorbable carbohydrate about three hours before the anesthesia is begun. In practice I have found that the latter is best accomplished by giving either six ounces of coffee or orangeade to which has been added one ounce of lactose. The above procedure should assure the organism of a considerable store of readily available glycogen during the period of anesthesia.

If we grant the plausibility of the argument up to this point it must necessarily follow that carbohydrate feeding should be instituted at the earliest opportunity after the operation. During the anesthesia, and for a period afterward, varying from a few hours to a few days in individual cases, oral feeding is impossible, so that we are, of necessity, forced to resort either to subcutaneous or rectal nutrition, or both. In the paper to which reference is made at the beginning of this article, the writer has discussed the various types of nutritives which theoretically may be used for subcutaneous nutrition, the conclusion being reached that glucose is the only form of nutritive which is clinically available for this purpose. Barlow recommended the subcutaneous use of glucose in 1895, and it has been in sporadic usage since that time; but it was not placed upon a scientific basis in surgical cases until the publication of Kausch, in 1911.

Sugar, in the form of glucose solutions, supplies energy to the cells and aids in tissue repair; it diminishes acidosis and thus tends to remove one of the factors in the cause of post-operative vomiting; it neutralizes certain poisons in the circulation (the conjugate glycuronates is the best example of this action); and it is possible

that it acts as a direct cardiac stimulant and food.[3] In addition to this, the solution introduced has many of the advantages and few of the disadvantages of saline solutions. Only a small percentage of the glucose injected hypodermically finds its way into the urine (usually from 2 to 5 per cent.). The remainder, as has been proved by the calorimetric experiments of Vezar and von Fejer,[4] is burned in the body, causing an increase in heat formation and a corresponding increase in the respiratory quotient.

Kausch[5] recommended 7 per cent. solutions intravenously and 4 to 5 per cent. solutions by hypodermoclysis. Solutions should be freshly prepared and sterilized, as they become more easily contaminated than does the ordinary saline. Strictly speaking, contamination is as easy in one as in the other, but owing to the fact that glucose is an excellent culture medium, accidental contamination is of more consequence than it is in common salt solution. Following the use of glucose by hypodermoclysis, there is no more pain or discomfort than after the injection of physiological salt solution. As much as two or three liters, representing from 90 to 210 grams of glucose, may be given during twenty-four hours, the amount depending on the character of the case and the urgency of the symptoms.

In addition to the hypodermic administration, glucose may be given by proctoclysis during anesthesia and for a period of several days after operation. It is given in 5 per cent. solution, dissolved in ordinary tap water, 12 to 16 ounces being introduced during the operation, and its administration continued, by the Murphy drip method, after the patient has returned to the ward. This method is so simple and has apparently been of such value that it should be used as routine after every severe major operation. From 300 to 500 calories a day may be introduced by one or both of the above methods without discomfort to the patient. This quantity, while insufficient to supply all the total energy requirement, is of great importance in the prevention of excessive nitrogen waste.

Three typical cases may be cited to illustrate the method of using glucose in routine practice.

Case I.—Male, aged twenty-four years. Well nourished. Operation for inguinal hernia. Sac adherent and operation prolonged. Twelve ounces of 5 per cent. glucose given by rectum as soon as patient returned to ward. Good recovery. Very little vomiting.

Case II.—Female, aged thirty-one years. Fairly well nourished. Acute appendicitis. Local peritonitis. Pulse rapid. Sixteen ounces of 5 per cent. glucose by rectum during closure of wound. Murphy drip, 5 per cent. glucose begun one hour after returning to ward. Good recovery. Very little vomiting.

[3] Gigon and Massini have brought forth arguments based upon laboratory findings which tend to prove that isolated muscle contains an enzyme by which it is enabled to utilize sugar directly, Biochem. Ztschr., 1913, lv, 189.

[4] Biochem. Ztschr., 1913, lii, 140. [5] Deutsch. med. Wchnschr., 1911, xxxii, 8.

CASE III.—Female, aged thirty-seven years. Poorly nourished. Pulse rapid. Removal of large ovarian cyst. Hypodermoclysis of four pints of 4 per cent. glucose during operation. Murphy drip, 5 per cent. solution after operation. Slow recovery.

In the above three cases glucose solutions were given simply as a routine procedure without regard to urinary findings or other symptoms of acidosis. In other words, it was given to those cases in which saline solution is ordinarily used as a prophylactic against post-operative shock.

Patients in whom a condition of acidosis may be suspected, should have a complete urinary analysis before operation, and if acetone be found, measures taken to diminish this condition as much as possible before operation is attempted. It should be remembered that these patients are poor surgical risks, and that, except in the most urgent cases, it is necessary to take measures to increase the available supply of fixed bases. This may be accomplished in two ways, namely, the administration of alkalies or of carbohydrates.

No attempt is made here to outline the complete treatment of acidosis, but it may be stated that it is customary to give an alkali in the shape of bicarbonate of soda until the urine becomes neutral. This will usually require much larger doses than are customarily given. Occasionally as high as 50 to 100 grams of sodium bicarbonate must be given before the reaction of the urine becomes neutral or alkaline.

In order to diminish the formation of acid bodies, large amounts of carbohydrate should be given, and it is exactly in those cases in which the administration of carbohydrates by mouth is impossible that the subcutaneous and rectal injections of glucose solutions find their indications.

The common conditions associated with acidosis are diabetes, nephritis, diseases of the liver, and after protracted vomiting. It is the last of these conditions that is seen most frequently by the surgeon and in which the administration of glucose plays its most important role.

Following operation, especially in the so-called "delayed chloroform poisoning," and in some cases which, for some reason, do not permit of oral alimentation, the urine should be carefully watched and at the first indication of acidosis, glucose solution and alkalies should be given either by mouth or rectum or directly into the circulation.

To recapitulate: (1) Glucose solution should be given as routine after every operation in which we have reason to fear more than the ordinary amount of post-anesthetic shock; (2) it should be given as routine in every case where post-operative oral feeding may be difficult or insufficient for a considerable period after operation; (3) it should be given as an emergency measure either before or after operation for the relief of an existing or threatened acidosis.